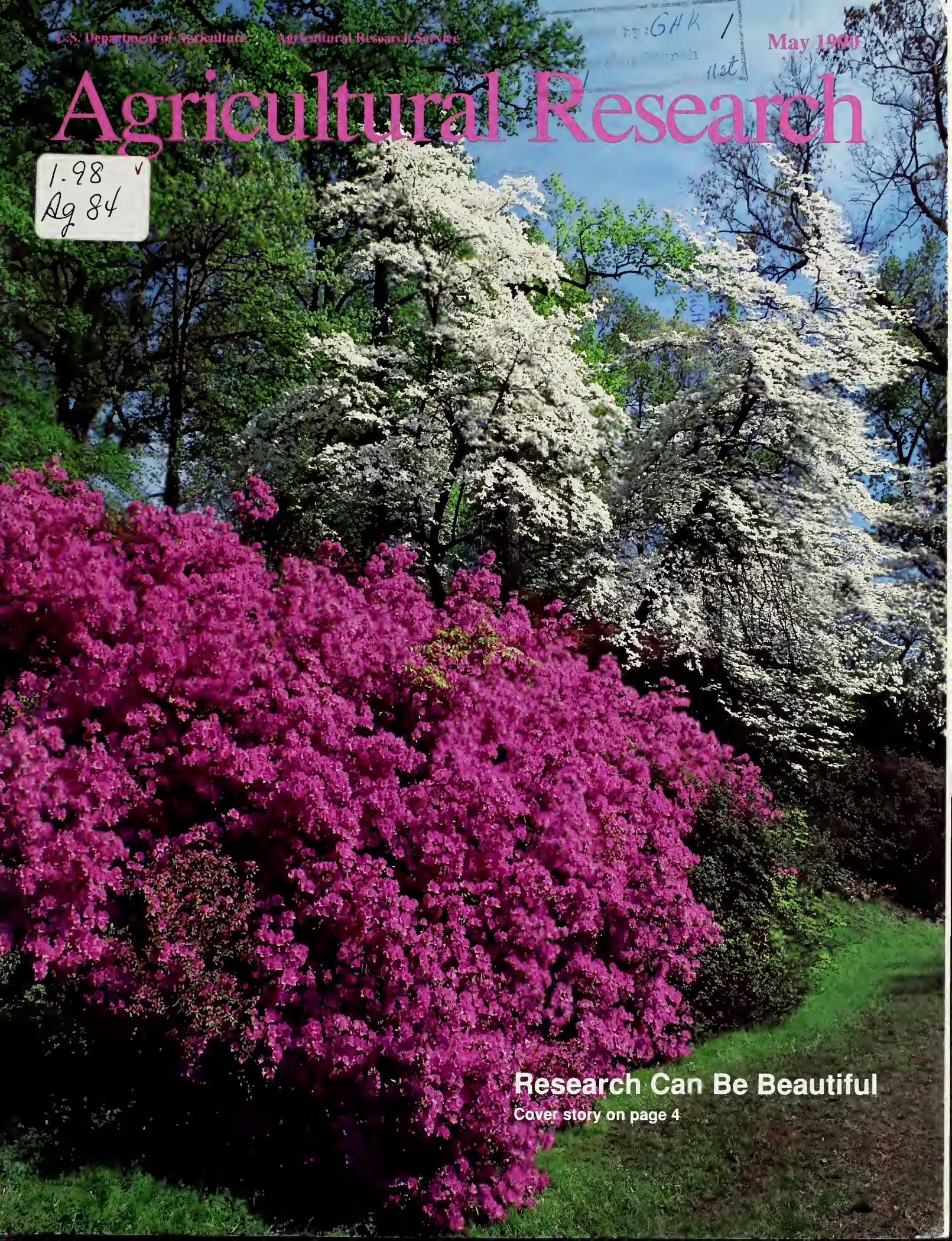
U.S. Department of Agriculture / Agricultural Research Service

May 1990

Agricultural Research



Research Can Be Beautiful

Cover story on page 4

Plant Hardiness Info at Your Fingertips

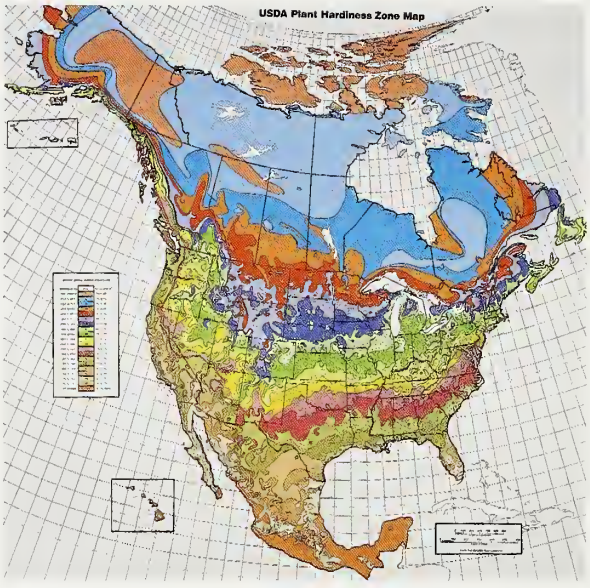
If ever a publication was destined for hard use, it's the USDA Plant Hardiness Zone Map. Many a copy ends up taped on office walls at commercial nurseries and greenhouses, smudged by fingermarks.

The map is a time-honored, decisionmaking resource that helps take some of the risk out of the matter of shipping plants. With it, growers decide when to ship living plants to different parts of the country so they will survive if planted on receipt.

This year, for the first time in 25 years, the U.S. National Arboretum has updated the Plant Hardiness Zone Map to make it more precise and more detailed. A portion of the new, detailed version showing the United States appears on pages 10-11 of this issue.

For the first time, the full map includes Mexico and Canada as well as Alaska and Hawaii, says National Arboretum director H. Marc Cathey, who oversaw the updating of the map.

"Our borders are contiguous and we share many plants, both native and introduced. It is appropriate not to isolate the United States when talking about climate," Cathey says.



USDA Plant Hardiness Zone Map. (K-3536-1)

Data from 14,500 stations went into this update, more than twice as many locations as were used for the maps produced in 1960 and 1965.

With the additional data, small areas of microclimate are indicated for the first time. These are cool spots due to mountaintop elevations and hot pockets caused by the heat of cities or protected valleys, Cathey explains.

"Our research has not turned up any signs of changes that might represent global warming," Cathey says. In fact, on both coasts, but particularly in the Southeast, temperatures averaged 5°F to 10°F cooler in the winter than on the previous map.

Meteorologist Mark Kramer of Meteorological Evaluation Services in Amityville, New York, which analyzed the data for ARS, says that "we aren't able to speculate about climate changes based on the map. The new USDA map tells us the weather has changed, but we don't know whether the climate is changing." Weather is day-to-day, month-to-month, year-to-year; climate represents the longer term, starting with about 30 years.

The wealth of new data used to create this issue of the map also allowed the borders of the zones to be drawn in much more precise detail than before. The intricate edges of the zones reflect where they interweave. "The new map should eliminate some inconsistencies between gardeners' experiences with local weather and the previous map," Cathey says.

The actual map, which unfolds to 4 feet by 4 feet, has 11 color-coded zones based on 10°F differences in average annual minimum temperatures. Two through 8 are subdivided into A and B regions based on 5°F temperature differences.

Zone 11 is new, representing an almost frost-free zone on the southern tip of Florida, southern California, all but the mountainous areas of Hawaii, most of the coastline of the Yucatan in Mexico, the southern Baja peninsula, and the Gulf of Mexico.

The data has also been added to the ARS Germplasm Resources Information Network (GRIN) database for the first time, making detailed winter hardiness information available about many plants. The map itself is not available electronically.

Incidentally, while most of the map's users recognize the map as a USDA publication, some may be surprised to learn the map is compiled by the U.S. National Arboretum. Yes, that parklike retreat in Washington, D.C., world-famous for its spring array of azaleas, is first and foremost, a research facility. You'll find more on the National Arboretum in this month's cover story, *Research Can Be Beautiful*, beginning on page 4.—By **J. Kim Kaplan,** ARS.

Agricultural Research

Cover: Each spring at the Agricultural Research Service's U.S. National Arboretum in northeast Washington, D.C., Glenn Dale azaleas flourish amid 444 acres of formally arranged trees, shrubs, and ground covers. Story on page 4. Photo by Tim McCabe. (K-3558-13)

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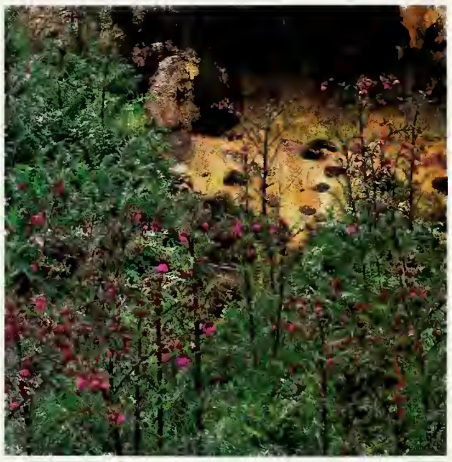

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Vol. 38, No. 5
May 1990

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Agricultural Research is published monthly by the Agricultural Research Service, U.S. Department of Agriculture, Washington, DC 20250. The Secretary of Agriculture has determined that publication of this periodical is necessary in the transaction of public business required by law of the Department.

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Subscription requests should be placed with the Superintendent of Documents, Government Printing Office, Washington, DC 20402. Please see back cover for order form.

Address magazine inquiries or comments to: The Editor, Information Staff, Room 316, Bldg. 005, Beltsville Agricultural Research Center-West, Beltsville, MD 20705. Telephone: (301) 344-3280. When writing to request address changes or deletions, please include a recent address label.

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Research Can Be Beautiful

When you drive down a city street and admire the showy flowers of a Whitehouse pear tree or find a magnolia tree thriving as well in Finland as it might in Florida, you are seeing the work of the National Arboretum.

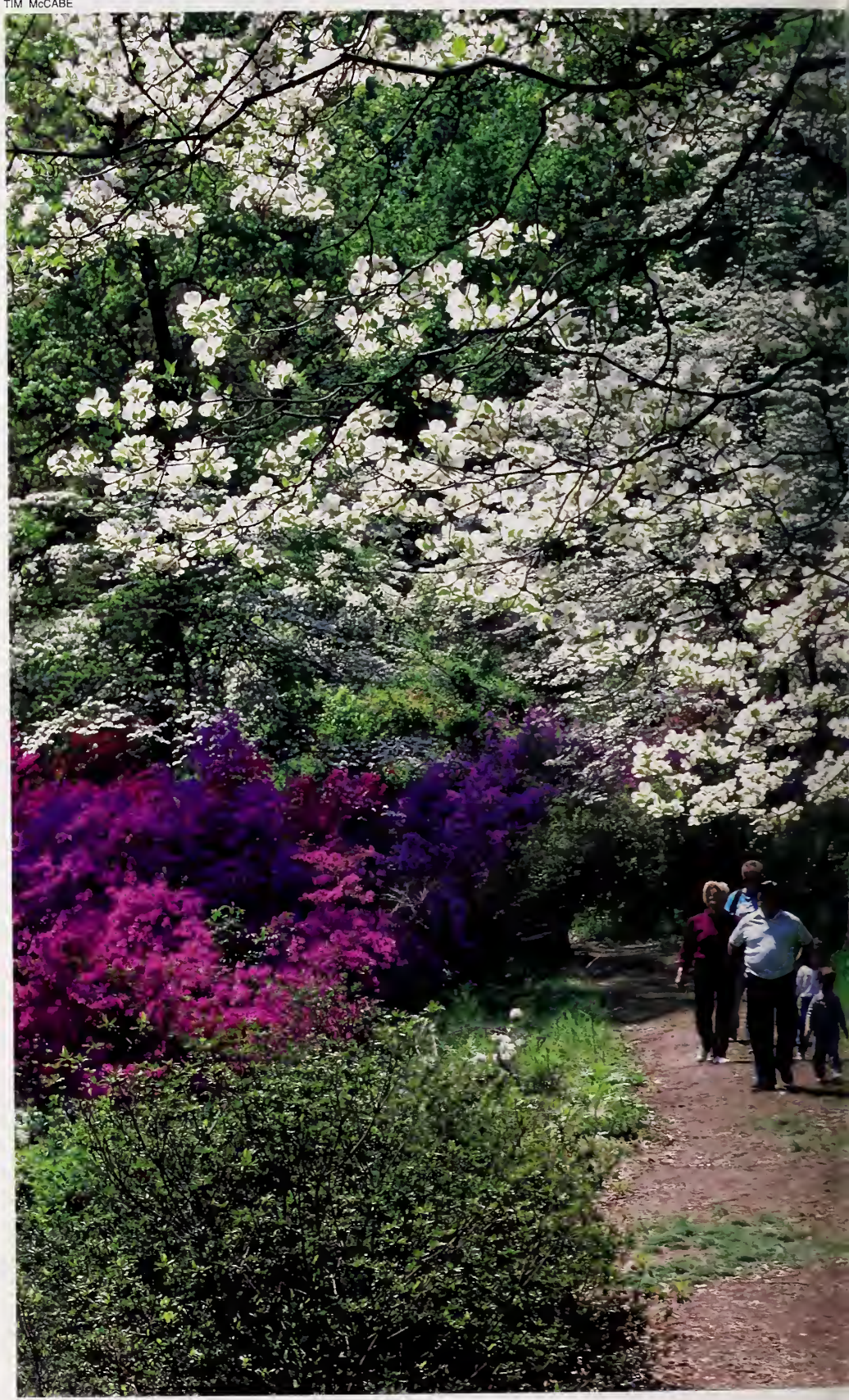
Located on 444 acres in northeast Washington D.C., the Agricultural Research Service's National Arboretum is a world class center for the improvement of the trees, shrubs, and ground covers that landscape streets, yards, and gardens all over the United States and the world.

The center is not just for creating an azalea of a different color or a magnolia that blooms longer, although National Arboretum researchers have done so. The Arboretum seeks woody landscape plants that are able to tolerate colder weather, or are more disease, insect, or salt resistant, or can survive the pollution of a congested city street.

In the 63 years since the Arboretum was established by congressional act, it has introduced more than 150 new landscape plant varieties, and 30 more releases are anticipated in the next 3 years.

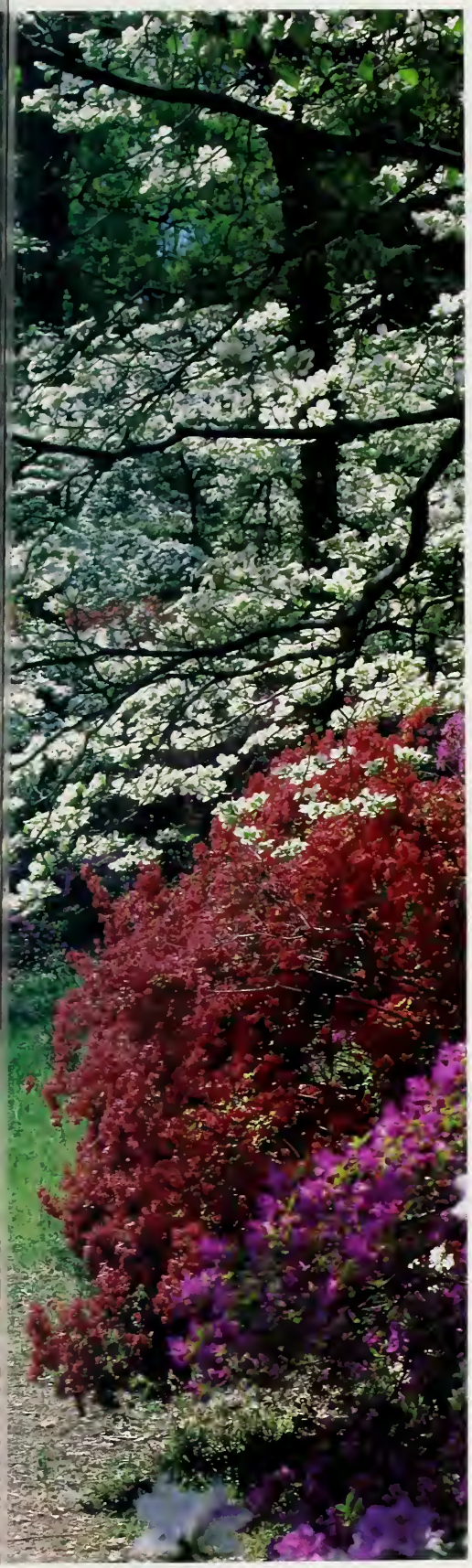
Work at the National Arboretum goes well beyond the development of new varieties. There are trips to distant lands to collect and preserve uncataloged plants, a herbarium that provides references for plant identification, and research projects that range from studying carbonized plant remains unearthed at Pompeii to finding out how tree wounds heal.

TIM McCABE



The azalea trail, a popular walk up to the Arboretum's Mount Hamilton, is a showplace for many varieties including Glenn Dale azalea hybrids. (K-3557-1)

At the National Arboretum, science is in the eye of the beholder.



And then there are the gardens that preserve and display the Arboretum's wares. They stretch from the formality of the Herb Garden and the Bonsai Pavilion to the informality of the Asian and Fern Valleys to the spontaneity of the New American Garden that was designed to thrive with minimal maintenance—an ideal many homeowners covet.

This last concept—called the New American Garden ethic by Arboretum director H. Marc Cathey—reflects the direction in which he has taken the center.

"These days we are creating gardens that are easy to live with and introducing new varieties to grow in them," Cathey says.

Instead of formal expanses of green lawns anchored by shade trees at the corners and shrubs against the house, Cathey advocates dynamic gardens that fit into small spaces but fill the garden with color all year around. "But it needs to be a garden without the constant need to water, fertilize, prune, and spray for insects and disease, all of which costs so much in time and energy," he explains.

One of the Arboretum's most enduring and abundant contributions to the country's landscape has been the development of three ornamental pear trees—Bradford, Whitehouse, and Capitol.

The Bradford pear is rated among the top10 most popular ornamental trees in the eastern United States—beautiful in all seasons and resistant to urban pollution.

John Creech, director of the Arboretum until 1980, first spotted the original seedling, with its cloud of snowy blossoms and resistance to fire blight disease growing at the Arboretum's nursery facility in Glenn Dale, Maryland. The tree was from seed that had been collected in 1917 by USDA plant hunter Frank Meyer in China, but it had largely gone unnoticed.

It was obviously a genetically elite specimen to Creech, far superior to any of the other seedlings growing from the same seed lot.

Creech budded trees from the original tree and eventually released the Bradford pear, named for a former superintendent of the Glenn Dale Station. In the 30 years since its release, millions of Bradford pear trees have been established along city streets, including two planted in front of the White House by Lady Bird Johnson in 1966.

Bradford pears, which mature at 30-50 feet, have sometimes proven too vigorous for power and telephone lines along streets.

So Arboretum researchers produced the Whitehouse and Capitol, which have the Bradford's advantages but are slimmer and shorter.

But tree breeding is not for the impatient, notes Cathey.

"It takes years, often 12 or longer, to develop and perfect a new variety of shrub, and a new tree can take 25 years before researchers are sure that they have a variety worthy of release to the nursery trade. Few, if any, private concerns can afford to invest in such long-term work," Cathey says. "That's why a place like the National Arboretum is so important. Here, we can take the time that others can't."

For example, Mohave pyracantha, or firethorn bush, with its Chinese red berries, disease resistance, and tolerance to cold, has become one of

the most widely grown new shrubs in the world. But horticulturist Donald R. Egolf began pyracantha breeding in 1959 and by 1963, he had 186 different crosses, of which 5 were selected as promising.

Then 7,900 seedlings of these 5 were sent to 20 cooperators—universities, plant specialists, and nurseries across the country—who evaluated them during a 5-year test period. In the end, just one, Mohave, was deemed worthy of being introduced to commercial nurseries.

In 1973, more than 10 years after the first crosses were made, Mohave became available to homeowners.

"While there are no exact figures, Mohave now certainly sells in the hundreds of thousands of dollars each year at nurseries," says William Flemer III, president of Princeton Nurseries and chairman of the National Arboretum Advisory Board.

The Arboretum does not sell its introductions, either retail or to commercial nurseries. "We simply make them available, point out their potential, and encourage the industry to pick them up," says Cathey.

ERIK NEUMANN

The Gotelli Dwarf Conifer Collection is an attraction throughout the year.

Sometimes breeding is directed to fill a specific need or request by the nursery industry, such as Arboretum geneticist Alden M. Townsend's work to produce an American elm that is completely resistant to Dutch elm disease while still offering the well-known stately profile.

Until the 1940's, when Dutch elm disease wiped out so many of them, an estimated 77 million elms lined the streets of American towns and cities. Now there are only a few million left in the entire country.

And the elms were replaced with maples, sweetgums, and honeylocusts, trees with an average lifespan of 14 years in street settings as opposed to 50 to 70 years for the American elms.

This spring, after many years of research and breeding, the National Arboretum expects to release to nurseries the first resistant American elm hybrids.

"These hybrids could mean that American elms reappear on the scene," says Townsend.

Another success story of the Arboretum's breeding program has been the crapemyrtle. Seventeen new hybrids of this most popular southern tree were released through 1987.

While the releases introduced new flower colors—blue-reds, peach blush red, and new shades of pink and purple lavenders—and new shapes from dwarfs to 35-foot towers, it is their disease resistance and cold tolerance that really offer potential.

These new varieties are the first to be resistant to powdery mildew, a disease that encrusts and kills the flowers and leaves of common crapemyrtles, according to Egolf.

"We started out looking for disease resistance, but we got a lot more than we bargained for when after four to five generations of breeding, we unlocked these new flower colors," he says.

Some of the hybrids also tolerate the cold better. They withstood

Friends of the National Arboretum

The Friends of the National Arboretum (FONA) is an independent organization of interested people that supports the Arboretum's programs. Over the years, FONA has helped finance projects such as plant collecting trips to Korea, China, and the British Isles and the erection of the National Capitol columns at the Arboretum. Donations have also been channeled through FONA to create fellowships and internships at the Arboretum. FONA's assistance has furthered many programs in research and has helped educate the public about the Arboretum's work.

temperatures well below 0°F, when common crapemyrtle varieties die back. An added bonus with some of the new varieties is that, as their bark peels away in winter months, sinuous and mottled patterns of brown, cinnamon, and tan emerge on the trunk.

"From now on," Egolf says, "crapemyrtle is no longer just a summer flowering plant."

Plant Hunters

To fuel the breeding program and to help preserve plants that could disappear in the wild, National Arboretum scientists make collection trips, in particular to the Orient, where so many North American ornamentals originated.

Plant hunters like the Arboretum's chief horticulturist Sylvester G. March scour remote areas in Japan, Korea, and China seeking the edges of a variety's

TIM McCABE

Botanist Roland Jefferson (left) and horticulturist Donald Egolf examine cherry tree seedlings grown from seeds collected by Jefferson in Taiwan. (K-2537-9)

KEITH WELLER

Latrobe's Capitol Columns Rededicated

The Corinthian columns quarried from Virginia sandstone lay abandoned outside the Capitol's power plant for 15 years. In 1973, they were trucked to the banks of the Anacostia River near the U.S. Botanic Garden's Nursery and left to sink into the mud.

These 24 10-ton columns once graced the East Portico of the Capitol facing the Supreme Court. Twenty-seven presidents swore their oath of office in front of them (until the ceremony was moved to the West Front). But in 1958, the sandstone columns, beginning to deteriorate from exposure, were pulled down and replaced with white marble ones.

KEITH WELLER

Plans were made, remade, and scuttled again for the disposition of the hand-carved columns. They ended up forgotten in the mud.

Forgotten except to people like Mrs. George Garret, an honorary member of the Friends of the National Arboretum (FONA). For more than 20 years, she campaigned for public display of the columns at the Arboretum.

Mrs. Betty Rae, president emeritus of FONA, says that the columns have too much historical value to "just let the sun, wind, and rain erode them away or for them to be carved up for souvenirs." FONA raised more than $66,000 to crate and move the columns to the Arboretum and then $2 million more for the construction of the display.

The late Russell Page was commissioned to create an appropriate classical display for them.

On June 14, the Capitol columns will be rededicated as part of an acropolis at the top of the Great Meadow of the Arboretum, according to FONA's current codirectors, Mrs. Nancy Ireland and Mrs. Gay Barclay.

Now free standing, the columns duplicate the pattern they formed on the east side of the Capitol. The ground around them is paved with 500 marble slabs, more than 200 years old, that formed the steps to the Senate until they were removed in 1956. From the base of the columns, a freestanding fountain flows down to a reflecting pool.

range where they may find specimens with desirable traits.

Traveling more than 2,170 miles during one trip in 1978 to the west-central and southern coast of Japan in areas that westerners have probably never explored, March collected specimens from 200 genera. His finds included a creeping form of *Vitex rotundifolia* with silver-gray leaves and blue flowers that should be useful as a binder and ground cover for sandy soil.

The collection of cherry trees has been greatly expanded by Roland M. Jefferson, who made several trips to Japan, Korea, and Taiwan before he retired in 1988.

Among his specimens, he brought back budsticks that may extend the flowering cherry tree's range into the coldest northern states and central Canada, areas where growing such trees has been impossible. And he found a dwarf cherry whose roots will tolerate wet locations. Not only is it an exceptional landscape tree, its fruit has a distinctive flavor that may be of interest to the food and beverage industry.

Jefferson's work in flowering cherry trees also enabled the United States to return a favor to Japan.

In January 1981, representatives from the Tokyo Metropolitan Government's Park Service sought cuttings from the flowering cherry trees that have graced the city of Washington D.C., since they were presented as a gift from Japan 70 years ago.

"Many of the varieties we have here have been lost in Japan to pollution and urbanization," says Jefferson, who helped them collect some 2,000 cuttings. There are more than 60 selections of flowering cherry trees established at the National Arboretum.

Also established on the Arboretum grounds is the oldest stand of Dawn Redwoods in the United States. Until 1945, when a USDA plant collector found a few living stands in China, the almost extinct 50-million-year-old trees were known to Western botanists only in fossils.

"Their stark, wild branches recreate images of a landscape that disappeared in North America thousands of years ago," says Cathey. "So far the trees, which are only 42 years old, have not produced fertile seed. We are still waiting for them to reach maturity."

Problem Solving

Trees in general may be tougher in the future and stand up to wounds better, thanks to the work of geneticist Frank S. Santamour, Jr. Santamour has developed a whole new understanding of wound healing.

"In the past, concepts from animal biology have been applied, almost unconsciously, to trees," he says.

For example, people put dressings on wounded trees, even though dressings have no value in helping a tree "get better." That's because trees, unlike animals, do not heal by replacing their damaged cells with new ones.

Instead, when a tree is wounded by a carelessly operated lawnmower or similar accident, it responds by "compartmentalization"—separating itself from the wounded area.

Trees first surround wounds with a chemical barrier to limit the spread of decay from the wound to surrounding healthy tissue. Then the cambium, or growth layer, forms a decay-resistant wall to protect new growth.

"We knew that some trees within a species can compartmentalize better and faster than other trees," Santamour says. "They are the ones that generally won't decay from a wound to the point where they might break, a benefit for the trees and for the people and property near them.

Santamour developed a technique by which tree breeders could test a tree for walling-off ability before spending the time and money to propagate it.

A chisel is driven through the bark and into the wood of a tree in its second season. After one more season, a cross section of the wounded area is taken.

If a brownish stain has spread toward the center, the tree has clearly not walled off the wound and the grower can eliminate it. If the tree has successfully contained the damage, the grower has a top candidate for propagation.

Among his other research projects, Santamour is looking at ways to tell male from female trees, an often impossible task until the trees mature. With trees such as the ginko, holly, and ash, the female trees, which produce large pods or fruit, are not desirable for landscaping. He is trying several biochemical approaches in hopes of coming up with

Geneticist Frank Santamour demonstrates a tough-tree test to determine the ability of trees to wall off their wounds and protect themselves from decay. (K-2251-8)

TIM McCABE

HOLL SHIMIZU

Entry area of the National Herb Garden.

an easy-to-use test to help nurseries sort male from female trees.

The Herbarium

The Arboretum is as much a repository of knowledge as it is a repository of trees and shrubs.

A herbarium is basically a reference library of plants. Dried, pressed plant specimens, carefully labeled with all known information, are stored in a moisture-free environment to provide a documented record for researchers and breeders.

The Herbarium, which contains more than a half million specimens, concentrates on plants of economic importance to man—ornamentals, food and forage, weeds, forest, industrial plants—as well as their wild progenitors.

"The point of the herbarium is to document correct identification of plants, so that everyone knows exactly what plants they are working with," says Cathey.

Botanist Frederick Meyer, who supervises the herbarium, recently completed the first comprehensive documentation of landscape plants grown in 13 southeastern states, with the correct botanical and cultivar names as well as the common name and synonyms.

"The list is designed to reconcile matters of identification and to correct mistakes and confusion over identifications and names," Meyer says.

With more than 4,700 entries based on the identification of more than 12,000 specimens, tasks like this are not simple.

Public Education

Although the Arboretum is primarily a research facility, it is also committed to educating the public about plants and gardening. Among its many programs is the "Living Legends" series, which takes visitors behind the scenes to greenhouses and laboratories.

The Arboretum regularly offers exhibits lectures, walks, and films. Volunteer guides from the Friends of the National Arboretum offer visitors

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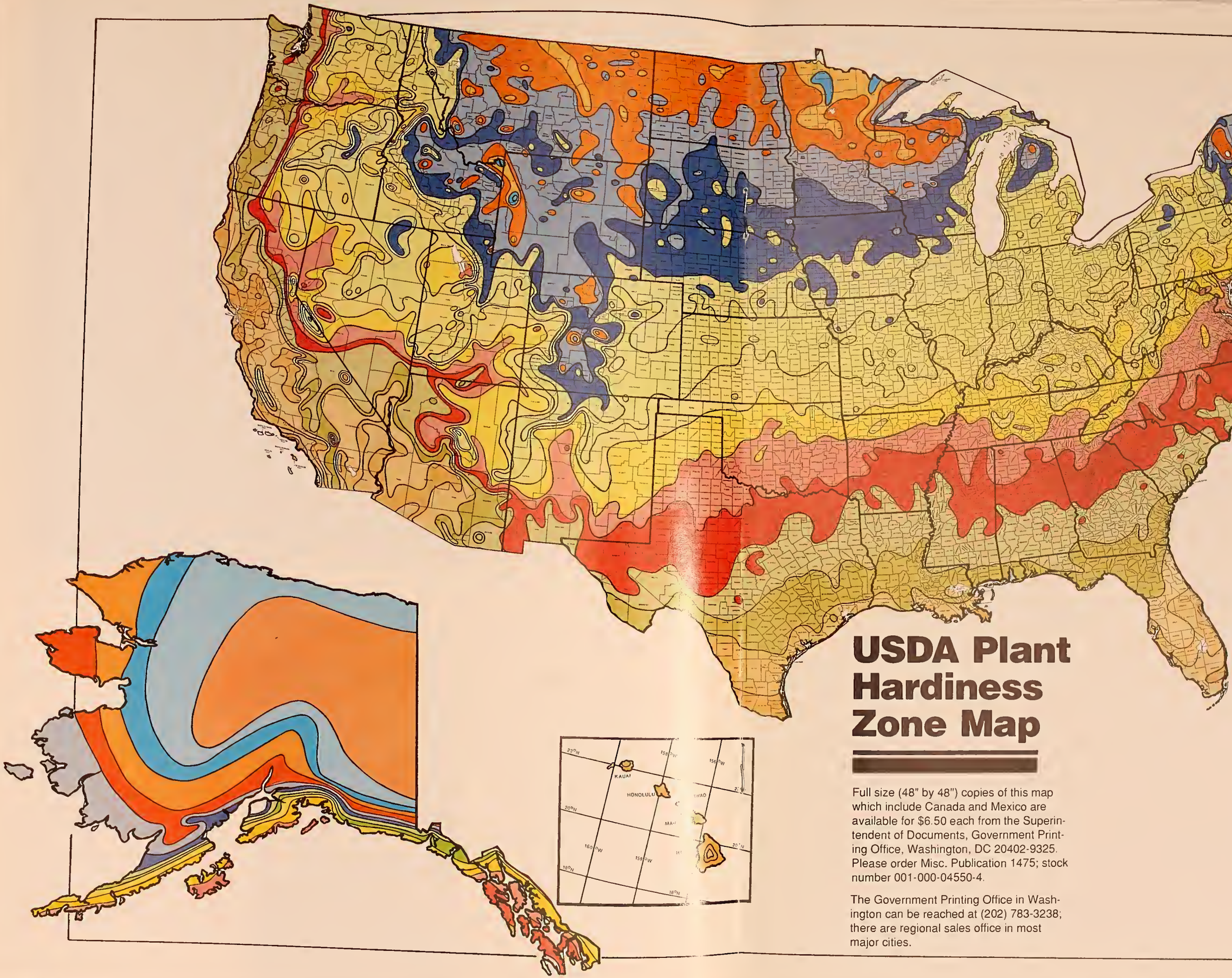


USDA Plant Hardiness Zone Map

Full size (48" by 48") copies of this map which include Canada and Mexico are available for $6.50 each from the Superintendent of Documents, Government Printing Office, Washington, DC 20402-9325. Please order Misc. Publication 1475; stock number 001-000-04550-4.

The Government Printing Office in Washington can be reached at (202) 783-3238; there are regional sales office in most major cities.

AVERAGE ANNUAL MINIMUM TEMPERATURE

Temperature (°C)	Zone	Temperature (°F)
-45.5 and Below	1	Below -50
-42.8 to -45.5	2a	-45 to -50
-40.0 to -42.7	2b	-40 to -45
-37.3 to -40.0	3a	-35 to -40
-34.5 to -37.2	3b	-30 to -35
-31.7 to -34.4	4a	-25 to -30
-29.0 to -31.6	4b	-20 to -25
-26.2 to -28.8	5a	-15 to -20
-23.4 to -26.1	5b	-10 to -15
-20.8 to -23.3	6a	-5 to -10
-17.8 to -20.5	6b	0 to -5
-15.0 to -17.7	7a	5 to 0
-12.3 to -15.0	7b	10 to 5
-9.5 to -12.2	8a	15 to 10
-5.7 to -9.4	8b	20 to 15
-3.9 to -5.6	9a	25 to 20
-1.2 to -3.8	9b	30 to 25
1.6 to -1.1	10a	35 to 30
4.4 to 1.7	10b	40 to 35
4.5 and Above	11	40 and Above

detailed information about the Arboretum's gardens.

The Arboretum's public face has always been its gardens, which are open every day of the year but Christmas.

There are stands of native hardwoods, marshes, meadows, and flowing streams to contrast with formal gardens that give visitors a view of the entire gamut of the woody ornamental plants.

The informal New American Garden, with its prairie grasses and other native plants, was designed to offer year-round interest combined with ease of maintenance.

On the opposite end in style, visitors find the essence of formality in the fascinating National Bonsai and Penjing Collection. The collection is one of the most outstanding outside of Asia.

Other areas include the Historic Rose Garden, the Herb Garden, the Boxwood Collection, the Perennial Gardens, and Asian and Fern Valleys. Each spring, as many as 60,000 visitors a day come to see the huge array of blooming azaleas.

And behind the administration building, the Court of Honor proudly displays the best of the Arboretum's own introductions.—By **J. Kim Kaplan,** ARS.

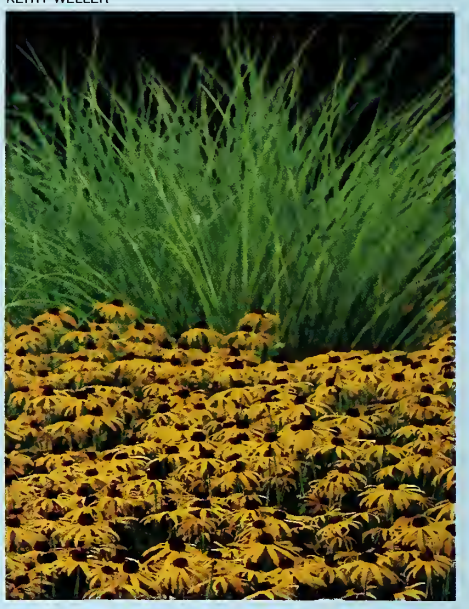
H. Marc Cathey is at the U.S. National Arboretum, 24th and R Streets, N.E., Washington, DC 20002 (202) 472-9100. ◆

Snow decorates an evergreen walkway of the Asian Valley.

Outstanding Attractions

The Gardens of the National Arboretum range from the classical to the informal. Nine miles of paved road provide access to the 70,000 azaleas, 400 varieties of camellias,

KEITH WELLER



Goldsturm (foreground) and Morning Light—two of about 200 plants in the New American Garden. (K-3560-14)

300 crabapples, 700 hollies, and 1,500 dwarf conifers as well as dogwoods, magnolias, maples, viburnums, flowering cherries, and many other landscape plants.

In each season, the Arboretum's more than half-million annual visitors find a different landscape to teach them the breadth of gardening.

Asian Valley

A winding walkway provides a picturesque view of Asian Valley with its massed trees and plants that represent the temperate climate landscape plants of exceptional merit from China, Japan, and Korea.

The watercourse and the planting design complement the natural features of the valley.

Fern Valley

In the heart of the Arboretum is a peaceful natural valley through which a small spring-fed stream flows. Century old beech, oak, and tulip trees shade its bank. Landscaping the valley are more than 750 species of plants found growing naturally in the eastern United States. Most are native, although a few were introduced and have become naturalized.

The 4 acres of woodland are complemented by a 2 1/2-acre meadow garden where wild flowers flourish in the summer.

The National Herb Garden

There are three sections to the 2 1/2-acre National Herb Garden—the Knot Garden, the Historic Rose Garden, and the Specialty Gardens.

The Knot Garden features dwarf evergreens formally displayed in interlocking chains. From the reception area, which looks out over the garden, visitors can observe the traditional elegance of the garden design, classical patterns made fashionable in 16th century England.

The Historic Rose Garden contains more than 80 types of old roses, all of which predate 'La France,' the first hybrid tea rose, introduced in France in 1867. These roses were selected not only for their beauty but also for their historical importance as food, medicine, perfumes, and of course air fresheners.

The 10 Specialty Gardens are each based on a different herbal theme. These range from Dioscorides' Garden, which features representatives from the ancient plants listed in De Materica Medica written in A.D. 60 to the Beverage Garden with plants from common hops to licorice that are used to make teas, wine, beer, liquor, and liqueurs.

Bonsai and Penjing

In commemoration of the U.S. Bicentennial, a rare and priceless gift of 53 bonsai was presented by the Nippon Bonsai Association of Japan. A narrow stone path representing a dry riverbed brings visitors into intimate contact with the 60- to- 360-year-old displays. At the end of the garden path just inside the shelter, rests the great Japanese red pine that was a gift from the Japanese Imperial Household. This was the first to leave the Imperial Household in 100 years.

PETER BLOOMER

A figurine of a musician kneels beneath a miniature Chinese elm. (K-3566-1)

The Penjing Collection was a gift from Dr. Yee-sun Wu and Mr. Shu-ying Lui. It is distinguished from bonsai by the growing method, and now numbers 31 specimens, ranging in age from 15 to 100 years.

The National Bonsai Foundation has donated funds for the construction of a pavilion to display the North American Bonsai collection and house classrooms and display greenhouses.

The Azalea Collections

Each spring, the Arboretum becomes ablaze with color as the Glenn Dale azaleas burst into bloom in shades from pure white through pink and red to deepest purple. The Glenn Dale azaleas are the end product of more than 400 large flowered, cold hardy azaleas selected and introduced by the National Arboretum.

The Arboretum also features a garden of the best late-flowering Japanese azaleas as well as a group of American species in a small valley running down to the south arm of Horseshoe Pond.

Gotelli Dwarf and Slow-Growing Conifers

This collection, considered to be one of the finest of its type in the world, was donated to the Arboretum by William T. Gotelli in 1962. It consists of more than 1,500 specimens including varieties of fir, cedar, false cypress, juniper, spruce, pine, yew, and hemlock.

New American Garden

This garden was designed to illustrate front and backyard landscaping. Perennials, grasses, and small flowering and fruiting trees provide interest in the garden all year-round.

A major criterion in selecting the plants used was ease of maintenance. They flourish with little if any spraying for disease or insects, do not need staking, and require only a minimum of pruning.

Other collections at the Arboretum include the aquatic plants, the boxwoods; the perennials featuring daylilies, irises, and peonies; the daffodils and ivies; the hollies and magnolias; the dogwood garden, the cherry trees; and the maples.

Dying Elms

New Test Offers Hope

RICHARD NOWITZ

A killer is lurking out there in the trees, and Ing-Ming Lee aims to unmask it.

The culprit is a mycoplasmalike organism, or MLO. MLO's were first implicated in 1972 in outbreaks of elm yellows, then known as elm phloem necrosis, a plant disease that is devastating American elms. But Lee thinks the same MLO might also play a role in a host of other vegetative ills.

Ing-Ming Lee is no detective; he's a plant pathologist with USDA's Agricultural Research Service. Working at ARS' Microbiology and Plant Pathology Laboratory at Beltsville, Maryland, he's developed a tool to detect signs of the elm yellows organism, just as telling as smoke curling from a gun in someone's hand.

Starting with infected plant material supplied by Wayne A. Sinclair, a plant pathologist at Cornell University, Lee created a probe made of a fragment of DNA from the elm yellows MLO. Millions of copies of this specific DNA fragment are made by cloning the DNA in *E. coli*, a live bacterium. The copies of the DNA fragment are purified from the bacterium, and a special molecule is attached to each piece of this DNA to label it.

The labeled DNA probe is heated and put on treated paper already loaded with heated DNA from a plant or insect suspected of being infected with the disease. If the plant or insect is infected with elm yellows MLO, some of the MLO DNA on the treated paper will match the DNA code of the probe and will bind the probe to the paper.

A color reaction is used to show whether the probe is bound. Development of color on the paper means that the DNA from the suspected plant or insect came from the elm yellows MLO and that the plant or insect was infected with the disease.

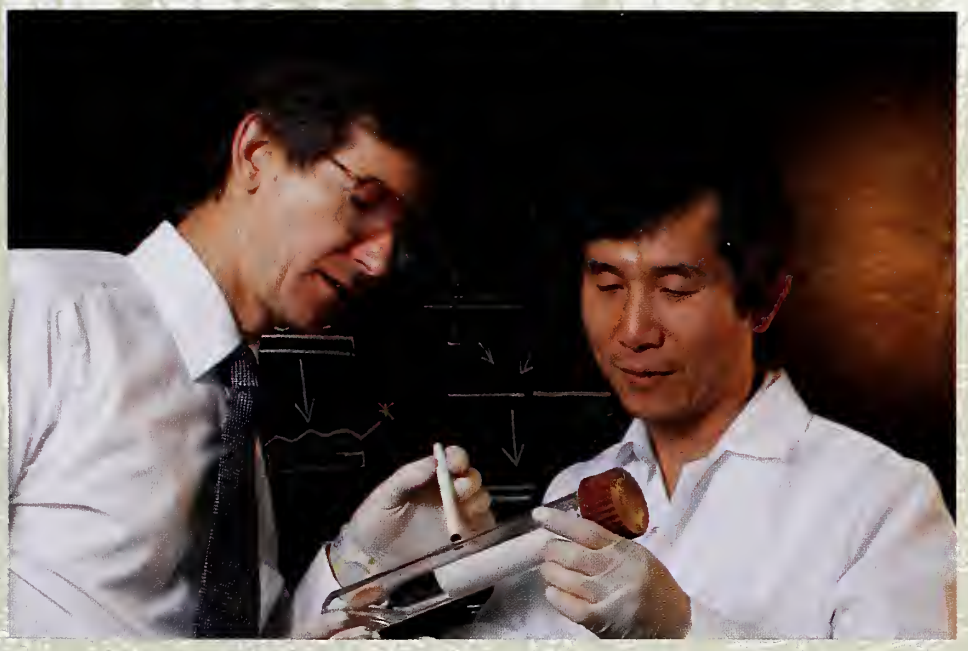
Lee isn't the first to develop DNA probes, but his is the first DNA probe for elm yellows, a disease that's augmenting the destruction wrought in American elms by Dutch elm disease. In fact, it's suspected that certain trees once believed to have fallen prey to Dutch elm disease were actually victims of elm yellows.

> MLO's ...behind a plant disease that is devastating American elms.

Unfortunately for tree owners, a tree infected with elm yellows may show no signs of a problem until the tree is beyond saving.

Lee's probe would offer a chance of finding the telltale MLO's before that point. Even more importantly, it could reveal whether seedlings are infected before they're ever planted.

"There is a similar disease in elms in Europe that's associated with MLO's," explains Robert E. Davis,



RICHARD NOWITZ

Plant pathologists Robert Davis (left) and Ing-Ming Lee study DNA probe hybridizations with samples from a suspected plants. (K-3544-7)

supervisory plant pathologist at the Microbiology and Plant Pathology Laboratory. "Is it the same MLO we have associated with elm yellows? We simply don't know."

However, the Europeans are taking no chances. Because of the threat of bringing in the potentially different American MLO with its accompanying elm yellows disease, import of living elm materials into European and Mediterranean countries from the United States has been prohibited.

Lee's probe could be used to help unravel the mystery of the relationship between the American and European MLO's. DNA probes like Lee's could also be used to check other types of plants for MLO's.

"Imported planting stock is tested for pathogens, but sometimes you have to graft them to check for MLOs, and it may take up to 6 years to get an answer," says Davis. "This probe could give at least a preliminary answer in just a few days."

Scientists already know several facts about MLO's, so named because they resemble the bacteria-like mycoplasmas involved in animal and human diseases.

For example, MLO's, like mycoplasmas, have no cell walls. MLO's can be spread among plants by leafhoppers. These insects penetrate the phloem—the "veins"of an infected plant—and take the MLO's into their bodies, and later inject the MLO's into other plants via saliva as they eat.

But unlike mycoplasmas, MLO's cannot be grown in cultures in the lab for ease of study. And there are other puzzles still to solve. For many MLO's, scientists do not know the identity of the insects that spread them. To further complicate matters, infection with a given MLO may not always cause the same problems.

"In one experiment by Wayne Sinclair and Ed Braun at Cornell University, the MLO associated with elm yellows in American elms was deliberately put into some Chinese elms," notes Davis. "It didn't kill the Chinese elms, and symptoms were different from those seen in American elms."

That finding raises a key question: Can the same MLO be causing more than one plant disease?

"We know there are more than 300 plant diseases worldwide associated with MLO's," says Davis. "But we don't know how many MLO's there are. Dr. Lee's elm yellows probe and other MLO disease probes developed in our laboratory can help show if the same or a related MLO is at the root of different plant diseases, as well as what insects may be spreading various MLOs."—By **Sandy Miller Hays**, ARS.

Ing-Ming Lee and Robert E. Davis are in the USDA-ARS Microbiology and Plant Pathology Laboratory, Rm. 252, Bldg. 011A, Beltsville, MD 20705 (301) 344-2745. ◆

JACK DYKINGA

Rare Sacramento Mountain thistles in New Mexico. (K-3306-1)

Protecting Endangered Plants

For some species, pollinating bees may be the deciders between survival and extinction

In the past several hundred million years, plant species have come and gone naturally, without help or hindrance from human beings, but we may be implicated in many of the more recent cases of plant extinction.

Plant loss due to destruction of habitat is a well-known occurrence in some tropical countries, where thousands of square miles of land containing numerous species are cleared annually. In the United States and similarly developed countries, factors that are less apparent may take a toll on plant diversity.

It's possible that some rare plants are becoming even rarer because of our use of insecticides—not herbicides. For example, if sprays against marauding grasshoppers are applied when rare plants are flowering, these insecticides may also kill the wild bees and other insects needed by native plants to transfer pollen from plant to plant.

"When this happens, plants that require pollination cannot produce seeds and entire plant species could slowly disappear because old plants are not replaced," says Agricultural Research Service entomologist Vincent J. Tepedino.

For many plant species that reproduce sexually, pollen must be transported from one flower to another.

After hand-pollinating thistles, biological technician William Bowlin attaches a net to prevent further pollination by insects. (K-3312-19)

Some botanists think that perhaps three-quarters of all flowering plant species rely on insects to perform this vital service.

"Commonly, native bees serve as six-legged John Aldens. These insect intermediaries visit flowers to collect pollen and nectar that they use as food for themselves and their offspring. As they visit the flowers, pollen that incidentally accumulates on their body hairs is deposited on other receptive flowers. Without bees, flowering plants would produce few fruits and seeds," says Tepedino.

A small research project has been projected by concerns about indirect harm from toxic sprays to nontarget organisms like threatened and endangered plants and their pollinators. Its objective is to verify whether these plants typically require insect pollinators to produce seed.

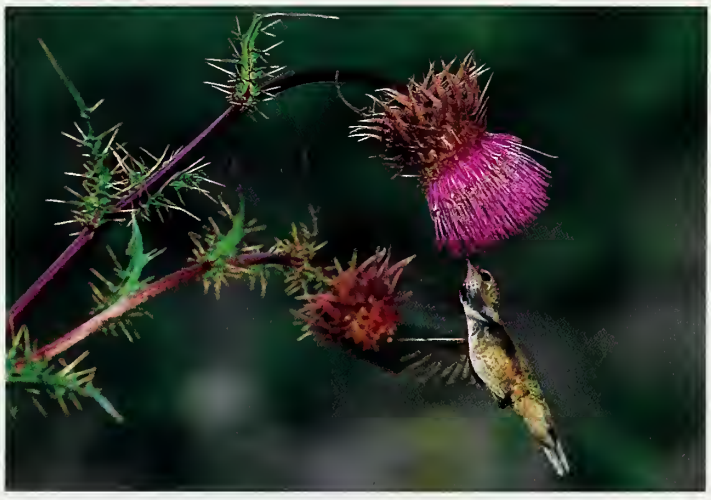
"If we discover that flowers of these rare plants produce about the same number of seed whether visited by insects or not, then we need not be concerned that spraying will affect their ability to reproduce sexually," says Tepedino.

Scientists will also identify the insect pollinators and learn about their life cycles and flight ranges. The facts will help in timing the insecticide application and determining how far away from bee nests it must be.

"Our goal is to identify and gather information on those threatened and endangered plant species most vulnerable to insecticides targeted for grasshoppers," says Tepedino at ARS' Bee Biology and Systematics Laboratory, in Logan, Utah. He says they are studying plants in Nebraska, Colorado, Utah, Idaho, Arizona, and New Mexico, homes to about 40 plant species that the U.S. Department of the Interior's Fish and Wildlife Service considers threatened or endangered. The region of study also contains rangelands where grasshoppers may require control measures when populations soar.

Tepedino and fellow entomologist Terry L. Griswold have studied eight plant species and their associated insect pollinators during the past two summers and hope to complete an additional six over the next two summers. They are helped by what Tepedino calls his "bee swarm"—a cadre of dedicated students and field technicians that include Susan Geer, William Bowlin, Bonnie Snow, and Etta Sechrest.

JACK DYKINGA



Hummingbirds are also involved in the pollination process. (K-3307-1)

The work thus far has taken them from the sandhills of the Nebraska Panhandle, to the peaks of central Utah and southern New Mexico, to the deserts of southern Utah.

"One thing that has truly surprised me is the beauty of many of these species," says Tepedino. "I had anticipated working on the ugly ducklings of the plant world."

JACK DYKINGA

Biologial technician Etta Secrest captures a bee in a vial before marking it with a distinctive blue dot of paint. (K-3309-14)

There are some reasons for thinking that as plants become rare they become less attractive to prospective pollinators. Concomitantly, their flowers may experience selection for characteristics more closely associated with wind pollination or self-pollination. Thus, it was expected they might lose their vivid colors and become small and nondescript.

"For the species we studied, this is obviously not so," Tepedino points out. Several of these species verge on the spectacular—it would be terrible to lose them!"

"With one possible exception, the plants we've studied so far have all turned out to rely primarily, if not exclusively, on wild native bees for pollination. This too is surprising for the same reasons," he says.

The bee species identified thus far represent a cross section of the North American bee fauna. Ranging widely in size, they include: bees that make their nests in the ground and bees that nest in holes in dead timber; bees with long tongues and bees with short tongues; bees that carry pollen on their hind legs and those that carry it on the underside of their abdomen; and bees that collect pollen and nectar from a variety of flowers and those that appear to be selective.

"Some of these bee species are very rare, and their occurrence on rare plants is particularly intriguing," says Griswold, who has identified several previously unknown bee species and some that have been collected only infrequently in the past.

For example, a new species in the genus *Perdita* has been captured while collecting pollen from the bearclaw poppy *(Arctomecon humilis)* in southern Utah. Also, the first females of the species *Hylaeus granulatus* were collected from the few remaining plants of clay phacelia *(Phacelia argillacea)* in central Utah.

"There is more than a moderate possibility that some endangered plants have pollinators that rely on them for most, if not all, of their pollen and nectar. If our additional studies corroborate this idea, then the insects are also endangered," says Tepedino.

This study is part of a 5-year research-demonstration project aimed at finding better and safer ways to control grasshoppers.

Project leader is Jerry L. Fowler, with USDA's Animal and Plant Health Inspection Service in Boise, Idaho. Other USDA agencies have pitched in, including the Economic Research Service, the Extension Service, and the Forest Service. The U.S. Department of the Interior's Bureau of Land Management, Fish and Wildlife Service, and National Park Service have also cooperated, as has the U.S. Environmental Protection Agency.

Now in its fourth year, the integrated pest management project was begun after severe grasshopper outbreaks in 1985 necessitated insecticide application on 13 million acres of western land.—By **Dennis Senft,** ARS.

Vincent J. Tepedino and Terry L. Griswold are at the USDA-ARS Bee Biology and Systematics Laboratory, Logan, UT 84322-5310 (801) 750-2559. Jerry L. Fowler is at USDA-APHIS, 3380 Americana Terrace, Boise, ID 83706 (208) 334-9644. ◆

Revealing the Mayhaw Secret

JERRY PAYNE

Many Americans are familiar with such exotic fruits as papaya, passion fruit, and mango. But mayhaw?

A wild, native fruit of the lower southern states, the mayhaw has long been a well-guarded secret of ardent mayhaw jelly lovers. Now an ARS scientist says it's time to end the secrecy and open the door to potential mayhaw farming.

"Mayhaws are a wonderful fruit, and they are rapidly growing in popularity," says Jerry A. Payne, an entomologist at the ARS Southeastern Fruit and Tree Nut Research Laboratory in Byron, Georgia. "And it's no wonder: The fruit sells for $5-8 a gallon and the jelly for $7-8.50 a pint."

The fruit is normally found growing on thorny trees in acid soils and shallow ponds. But he says planting and treating mayhaws as orchard fruit will produce higher yields and additional income for growers from North Carolina to Texas.

Working with Gerard W. Krewer of the University of Georgia Extension Horticulture Department, Payne found that certain mayhaw varieties, under orchard conditions—with trees 15 to 20 feet apart—could lead to yields of up to 8,000 pounds of fruit per acre when in full production. An acre can support about 145 trees.

Mayhaws are the size and color of ripe half-inch cherry tomatoes and have a tart flavor "that makes one of the best jellies in the world," Payne says. Besides jelly, mayhaws can be made into wine, butter, syrup, and pies and can be mixed with other fruit jellies to enhance their flavors.

Nutritionally, mayhaws are wise eating. Studies by food technologist Ron Eitenmiller of the University of Georgia found mayhaws to be rich in potassium, calcium, and vitamin C. The fruit is also a good source of beta carotene, which the body converts into vitamin A. Four ounces of mayhaws provide 10 percent of the recommended dietary allowance of vitamin A.

Mayhaws are susceptible to many of the insects and diseases that attack similar fruits such as apples and plums.

Farmers or homeowners interested in planting mayhaw trees should find them widely available within the next few years. The trees are stocked by a small number of nurseries in the Southeast.—By **Matt Bosisio,** ARS.

Jerry A. Payne is at the USDA-ARS Southeastern Fruit and Tree Nut Research Laboratory, P.O. Box 87, Byron, GA 31008 (912) 956-5656. ◆

Year Round, It's Easter Lily Time

Consider the lilies of the field, how they grow; they toil not, neither do they spin. Even Solomon in all his glory was not arrayed like one of these.

No longer must they grow in the field. And not only in pure white, but they now come in brilliant red, creamy yellow, and royal lavender. Instead of the usual 2 to 3 years of growth, lilies can now be brought to flower in 280 days.

Miraculous? Some may think so, but ARS horticulturist Mark S. Roh says a technique of sequential temperature changes is responsible.

Roh doesn't begin with regular lily bulbs, either. Instead, he uses bulbils, tiny bulbs that appear after flowering on the stem of the plant where the leaves sprout.

At his Beltsville, Maryland, lab, he packs the bulbils in moist peat moss and subjects them to alternating low-high-low temperatures.

Then Roh transfers the bulbils to 4- or 5-inch pots filled with soil-peat-perlite mixture. About 100 days from the first sign of shoots, two to four beautiful, graceful lilies on strong stems bloom in each pot.

"It's the sequential temperature changes that force the lilies to flower in such a short time," Roh says. He has applied for a patent for the treatment which, he has used on both Easter and Asiatic hybrid lilies.

Roh has developed nine new lily varieties, all producing bulbils. Not all commercial hybrid lilies produce bulbils naturally.

"An important advantage of this treatment is that we completely eliminate the field phase of growing lilies," he explains.

In the field, lily bulbs are prey to disease and insect infestation and summer sprouting, which can lower bulb and plant quality. Controlled greenhouse growth eliminates major threats such as lily viruses and soilborne fungal diseases that plague lilies growing in the field.

With Roh's temperature treatment, lilies can now be available throughout the year, not just around Easter season, which may also bring down the seasonal price that consumers now pay.—By **Doris Sanchez,** ARS.

Mark S. Roh is with the USDA-ARS Florist and Nursery Crops Laboratory, Beltsville, MD 20705 (301) 344-3659. ◆

JOHN KUCHARSKI

Horticulturist Mark Roh with new lilies. (K-3564-1)

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